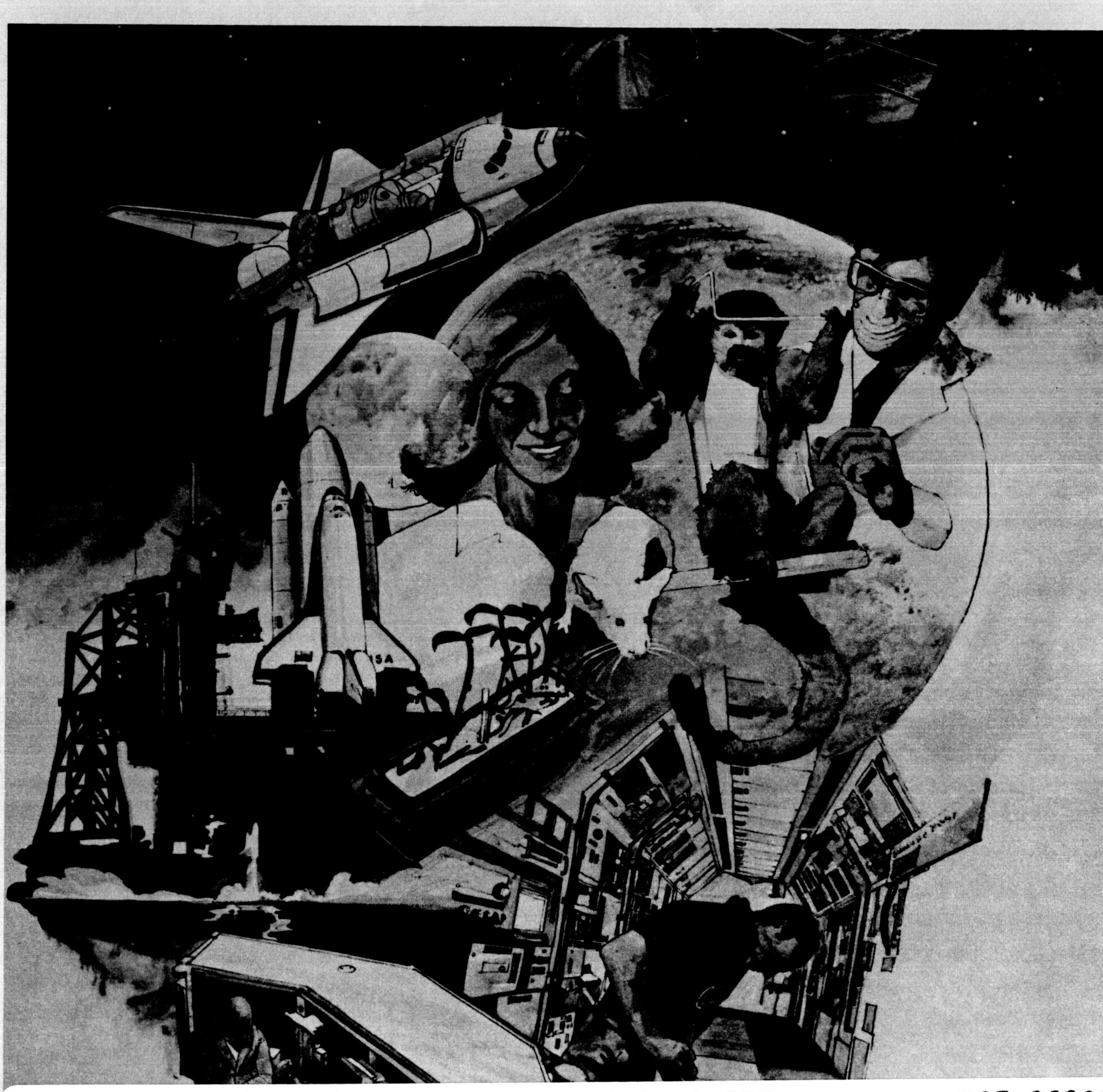
Ames Research Center
Life Sciences Flight Projects

NASA
National Aeronautics and
Space Administration



(NASA-TM-89289) LIFE SCIENCES LABORATORY EQUIPMENT CATALOG (NASA) 34 p Avail: NTIS HC A03/MF A01 CSCL 06B
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Life Sciences Laboratory Equipment Catalog

June 1987

FOREWORD

The purpose of this catalog is to provide a composite inventory of equipment available from the Ames Research Center for microgravity experiments using the Shuttle Transportation System (STS) Middeck and Spacelab. The equipment described was developed under the management of the Life Sciences Projects Office, Ames Research Center, National Aeronautics and Space Administration, Moffett Field, CA 94035.

Personnel from the Life Sciences Projects Office provided all data for this catalog, which is current as of the date of printing, March 1987. The Project Office wishes to express special thanks to Cheryl Pfeffer, who as a volunteer, collected all pertinent data for the catalog.

Further information concerning equipment and/or its availability may be obtained by contacting Mr. William E. Berry; Chief, Life Sciences Projects Office; MS 240A-3, Ames Research Center, Moffett Field, CA 94035; phone (415) 694-5736.

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INTRODUCTION

The Life Sciences Projects Office, NASA Ames Research Center, is responsible for developing and integrating nonhuman experiments flown aboard the Shuttle Transportation System (STS) Spacelab. Examples include experiments involving tissues and cells, plants, amphibians, rodents, and primates. Facilities represented within this catalog have supported experiments flown or to be flown aboard the following missions: Spacelabs 1, 2, and 3 (SL-1, SL-2, and SL-3); Spacelab Life Sciences 1, 2, and 3 (SLS-1, SLS-2, SLS-3); Spacelab J (SL-J); the International Microgravity Laboratory (IML-1); and the Atmospheric Laboratory for Applications and Science (ATLAS).

Ambient—Temperature Recorder

STATUS: *COMPLETE*
FLIGHT: *SLS-1, ATLAS*

The ambient-temperature recorder is a totally self-contained, battery-operated device that may be placed in almost any environment to provide a history of ambient temperature.

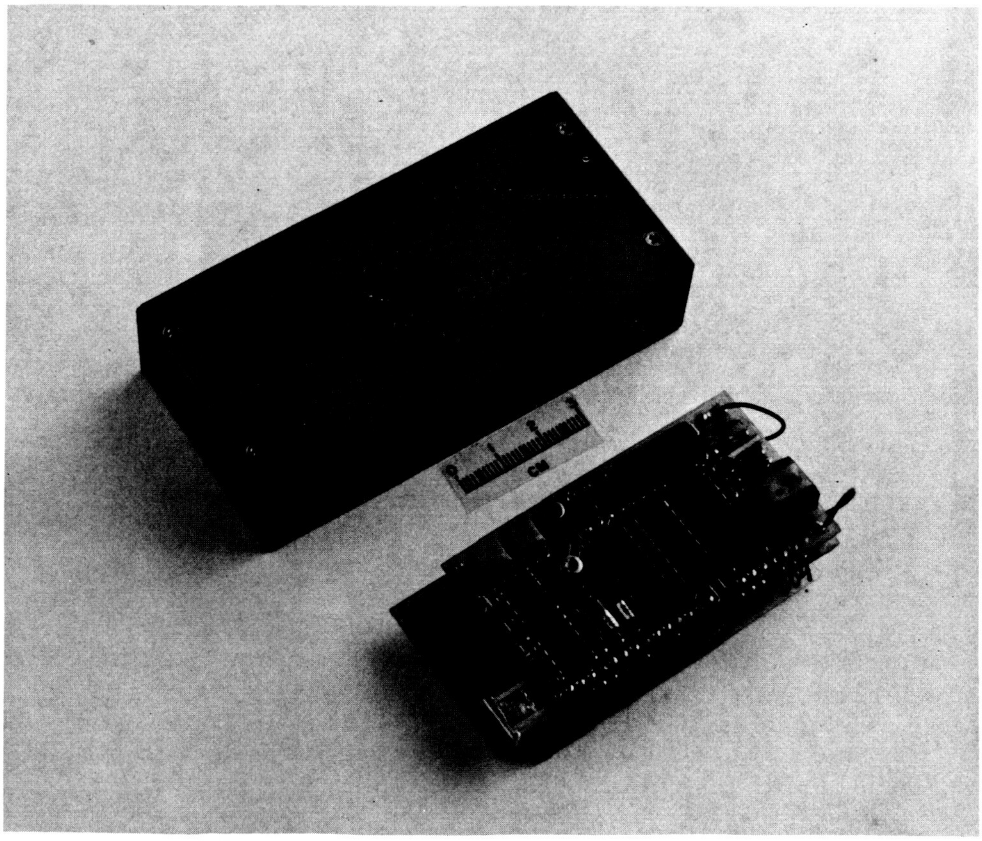
The unit periodically senses and stores (in its solid state memory) its own surface temperature. These stored values may be read out postflight by an external computer. The sample rate and temperature range can be modified, but the total number of samples is limited by the size of the internal memory. When the memory is full, the recorder goes into a low-power "hold" mode. The internal power supply consists of a lithium battery pack. The case is made of aluminum and is approximately the size of a package of cigarettes. The readout unit is an Apple II computer with a special interface card made within NASA.

Unit designation: ATR-2B
8 units in inventory

Specifications:

Temperature range	−15 to +45° C
Accuracy	±0.5° C
Sampling rate	27 msec to 15 min
Data capacity	2048
Data-acquisition period	21.33 days (maximum) at 25 min sampling rate
Size	2.5 × 5.1 × 10.2 cm
Weight	201 g

Ambient Temperature Recorder



Animal Enclosure Module

STATUS: *COMPLETE*
FLIGHT: *SLS-1 (Earlier Version STS-8)*

The Animal Enclosure Module (AEM) provides unique animal experiment capabilities on board the Shuttle in support of life sciences research in space. The AEM supports up to six 350-g rats and fits inside a standard middeck locker with a modified locker door. The AEM is composed of a stainless steel grid cage module, fan blowers, a layered filter system, interior lamps, and a water unit; food bars are glued on cage walls.

Total animal floor space is 125 in^2. A removable divider plate provides two separate animal holding areas (if required). Four fan blowers, operated by a switch on the front panel, create a slight negative pressure inside the cage, causing an air sweep to pull animal waste products into a collection plenum. Cabin air is exchanged with the unit through a filter system. High efficiency particulate air filters are in place to prevent any microbiological escape into the cabin atmosphere. Treated charcoal, within the unit, confines animal odors to within the closed system.

A light switch on the front panel operates the internal lamps. Investigation is in process to provide an automatic 12/12 timer operation.

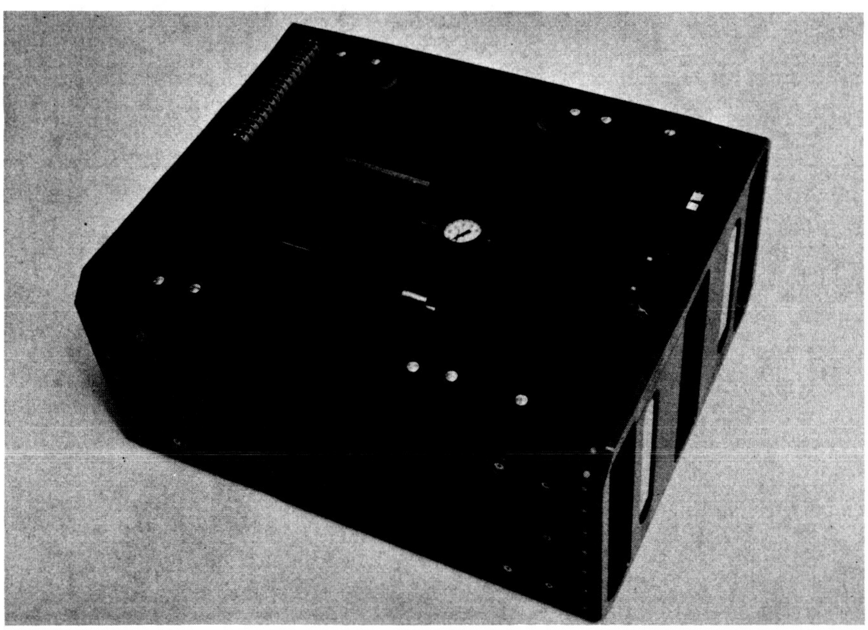
The AEM remains in the stowage locker during launch and landing. In orbit the AEM may be removed from the locker and viewed or photographed through the clear lexan cover which is over the cage. The unit has been demonstrated to fit within the General Purpose Work Station (for additional viewing purposes).

The original AEM unit was developed for the student program by the McDonnell Douglas Company. Units flown previously utilized potatoes as a watering source. The current unit has a 1500- and 2000-cc capacity automatic watering unit utilizing four "lixits" and a Becton–Dickinson blood bag for water storage. Water consumption will be monitored by observation of water levels.

Specifications:

Dimensions	24.50 × 43.69 × 51.05 cm
Weight (loaded)	26.8 kg (59 lb)
Power	35.5 W (min), 46.5 W (max)
Temperature	Orbiter middeck or Spacelab cabin (four internal fans circulate air through the AEM from the cabin)

AEM (Waterer, lexan cover installed)



Autogenic Feedback System

STATUS: *DESIGN*
FLIGHT: *Early Version flown on flights 51B and 51C*

The Autogenic Feedback System (AFS) is an ambulatory physiological monitoring system associated with the Autogenic Feedback Training (AFT) Experiment. It is designed to monitor and record eight human physiological parameters, including electrocardiogram (ECG), skin conductance (SC), respiration (R), finger plethysmography (BVP), skin temperature (T), and triaxial acceleration (X, Y, Z), plus the additional parameters of time (GMT) and event. The unit consists of a series of small electronic modules, a battery pack, and a tape recorder worn around the waist. The AFS is divided into two primary subsystems; the front-end electronics/feedback display and the recorder/playback system.

The front-end electronics include the analog and digital circuitry required to process the signals from the physiological transducers. Five of the physiological parameters are output to a feedback display worn on the wrist, enabling the astronaut to monitor his/her data. All signals are recorded onto a small multichannel analog cassette tape recorder. The associated playback system is a tabletop unit which reproduces the postflight raw analog waveforms. These signals are subsequently digitized and loaded into a computer for analysis.

The AFS is a self-contained unit requiring no interfacing with Shuttle systems. It is capable of recording data for a minimum of a 12 hr. day before a new tape cassette and battery pack are required. A special associated garment must be worn by the astronaut to accommodate the cabling from the physiological transducers and feedback display. Six AFS units will be built, four flight and two for Ground Support Equipment (GSE). The newly proposed unit will look like a wide belt of packet sections containing the various cassettes and recorders. The newer unit is intended to be lighter weight and less cumbersome than the original units.

The earlier version of the AFS was developed and flown on Shuttle missions 51B and 51C. The unit monitored the same physiological signals listed above, with the addition of thoracic respiration. The bulkiness of the unit, however, made it difficult for the astronauts to maneuver within the Shuttle environment. There are no plans to manifest the earlier unit on future flights.

AFS

Biotelemetry System

STATUS: *COMPLETE*
FLIGHT: *SL-3*

The Biotelemetry System (BTS) is a general-use system to monitor physiological functions of mammals on board the STS Spacelab. This system is designed to be used primarily within the Research Animal Holding Facility (RAHF). The BTS consists of three basic parts; the implantable sensor and transmitter within the animal, the antenna receiving system incorporated within the RAHF, and the data-handling system on board the Spacelab.

Each unit of the BTS can monitor one animal for one to four physiological functions. The implant includes a transmitter as well as appropriate sensors, the range of which can be 1 ft. or more. The antenna can be installed within one cage of the RAHF, and connected via cables to a receiver system whose output is compatible with the Life Sciences Laboratory Equipment (LSLE) microcomputer. The parameters measured can include body temperature; pressures (aortic, arterial, left and right ventricle, and right atrial); ECG, EOG; and EMG. The animal ECG rate can be up to 320 samples/sec; the other parameters are sampled once/second by the LSLE microcomputer. These data can be stored or downlinked in real time or near-real time. A pulse interval modulated FM radio signal is received from each animal cage being monitored.

The units have been successfully demonstrated in both rodents (rats) and small primates (squirrel monkeys) during ground tests, and were used successfully in Sprague–Dawley rats during the flight of SL-3.

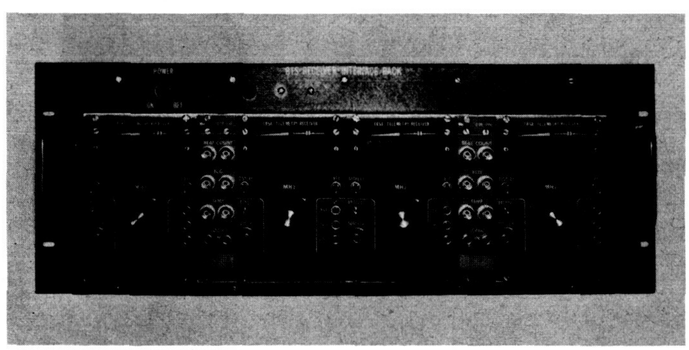
Specifications:

Size .... 48 cm wide × 36 cm deep × 18 cm high

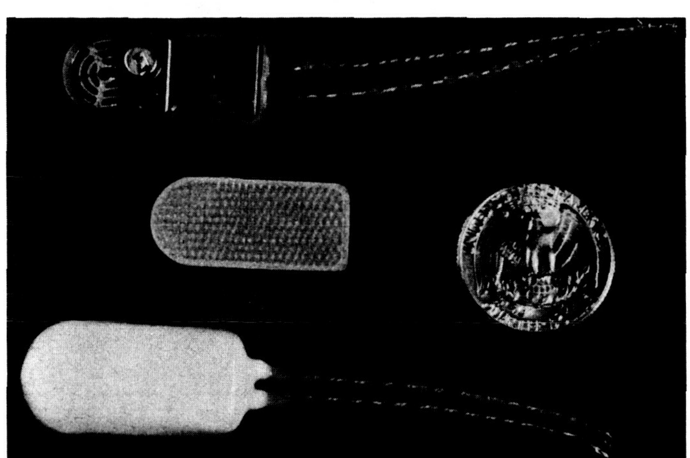
Weight .... 15.89 kg

Power .... 43 W

Biotelemetry System



Biotelemetry Implants



Compound Microscope

STATUS: *COMPLETE*
FLIGHT: *SLS-2*

The compound microscope, originally developed in support of the combined Cardiovascular Investigation for SLS-1, is a modified Carl Zeiss type-WL unit. The microscope is generally used in conjunction with the General Purpose Work Station (GPWS) and is mounted within the GPWS on a suction-base stand. A co-observation tube directs the object light beam both outside the GPWS through a sealed window, for visual observation and still photography, and to a video camera, whose signal is directed outside the GPWS. The microscope has a multiple-objective turret, coarse and fine focusing, and an adjustable illumination source operating off the standard Spacelab 28-VDC, which is available inside the GPWS.

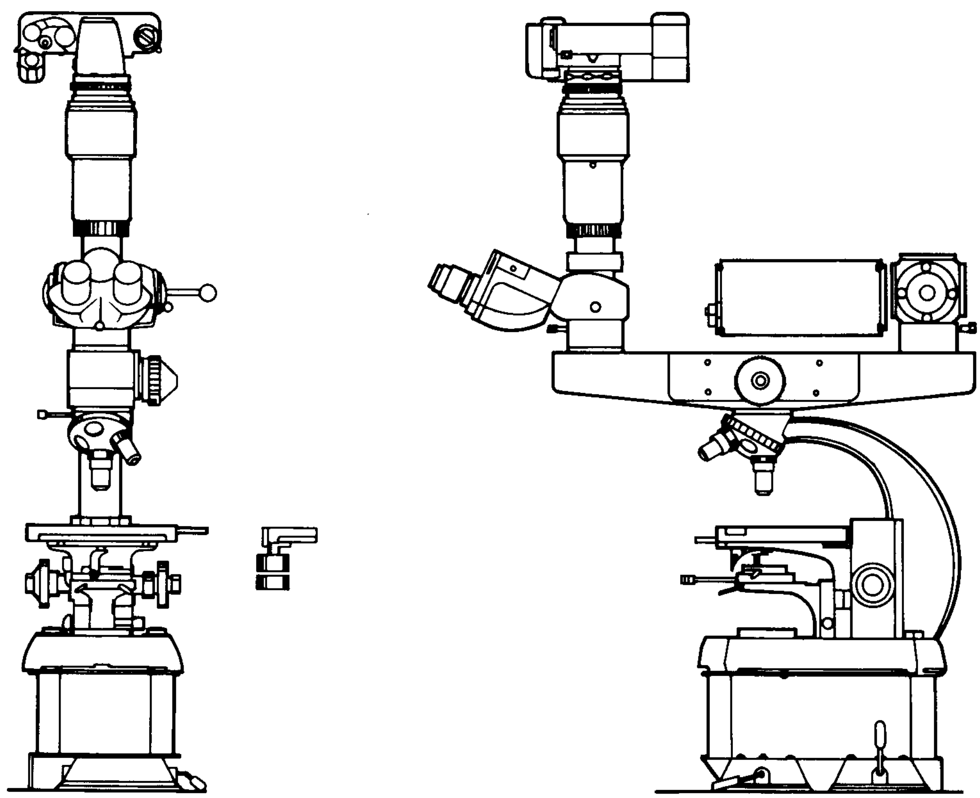
Specifications:

Size: .... 61 × 38 × 15 cm

Weight: .... 15.7 kg (34.54 lb)

Power: .... 17.2 W

Compound Microscope



Dissecting Microscope

STATUS: *DEVELOPMENT*
FLIGHT: *SL-J*

The dissecting microscope system will support general life sciences experiments requiring dissecting microscope capabilities such as gross examination, dissection, and image recording of tissues and other specimens. The system consists of the following pieces of equipment:

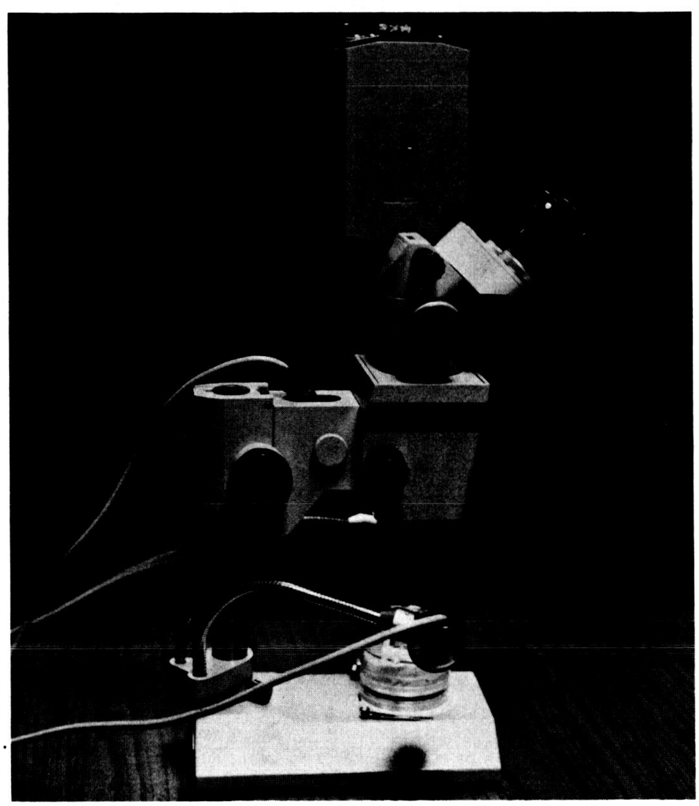
- Zeiss steriomicroscope, model SV8
- RCA video black and white camera
- Power box
- Microscope workstand

The system is modular and is stowed when not in use. During operations, the microscope and ancillary equipment are used in the General Purpose Work Station (GPWS). The microscope system features a continuously variable zoom of 8X-64X magnification. Viewing requires incident lighting provided by two 6-V, 10-W halogen lamps attached to the microscope column on flexible goosenecks which need not be removed in flight. The microscope has an adapter to accommodate the video camera. Real-time video can be downlinked during in-flight experimental operations. The microscope attaches to the GPWS by workstand suction cups. The power box will be designed to convert from Spacelab AC 400-Hz/3-phase power to power the video camera and microscope lamps.

Specifications:

Size	Approximately 48.26 cm high × 20.32 cm wide × 25.40 cm deep (microscope with stand and video camera attached)
Weight	Approximately 10 kg (all parts as above, 22 lb)
Power	400 Hz/3-phase power, approximately 40 W total

Dissecting Microscope



Dynamic Environment Measuring System

STATUS: *COMPLETE*
FLIGHT: *SL-3, SLS-2*

The Dynamic Environment Measuring System (DEMS) is an instrumentation package that will record and monitor Spacelab vibration, acoustic, and acceleration levels during launch and reentry. Data thus obtained may be applicable to determining the forces various biological systems experience under launch and reentry loads.

The DEMS consists of two cassette data tape recorders, one triaxial vibration transducer with signal conditioners, one triaxial accelerometer, one acoustic sensor and preamp, a controller, launch/reentry detector, power supply, and a slow-code time generator which modifies the Spacelab signal to a slow code suitable for tape recorders. The DEMS is designed to activate automatically at launch and reentry, but can also be manually controlled. Once activated, the DEMS will record data automatically for 90 min.

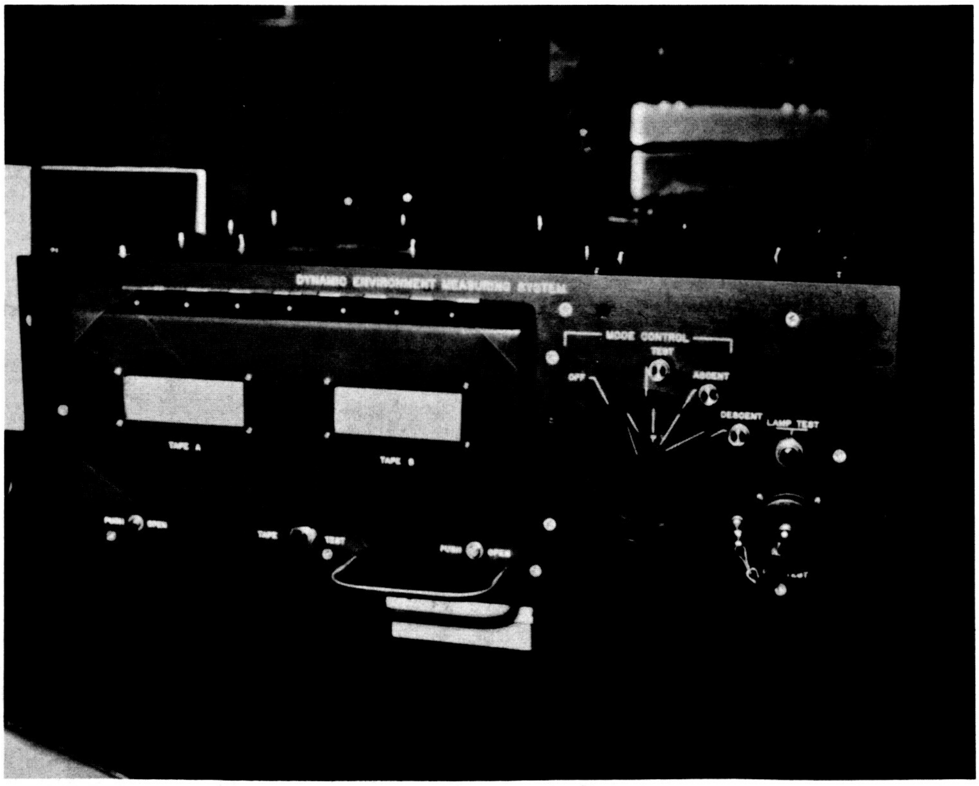
Specifications:

Size .... 36.5 × 44.2 × 15.9 cm

Weight .... 15 kg (33 lb)

Power .... 8.5 W

Dynamic Environment Measuring System



Frog Environmental Unit

STATUS: *DEVELOPMENT*
FLIGHT: *SL-J*

The gravitational biology/embryology experiment package, known as the Frog Environmental Unit (FEU) contains four major systems: centrifuge, adult frog holding unit, 0-G egg chamber storage, and the electronics. The centrifuge rotates at approximately 60 rpm and yields 1-G at the circumference, providing a control environment for embryos developing at 0-G. The FEU is temperature-controlled by a thermoelectric unit (TEU) linked to the Spacelab liquid cooling loop. The environmental control system will control the temperature within the range of 18–24° C throughout flight.

The adult frog chamber, in the upper right corner of the experiment unit, is a drawer-type compartment designed to accommodate four female frogs during a mission. The unit is insulated with damp sponges and the air flow is regulated. The box, for adult frogs, is removable and is opened in the General Purpose Work Station (GPWS) during experimental operations.

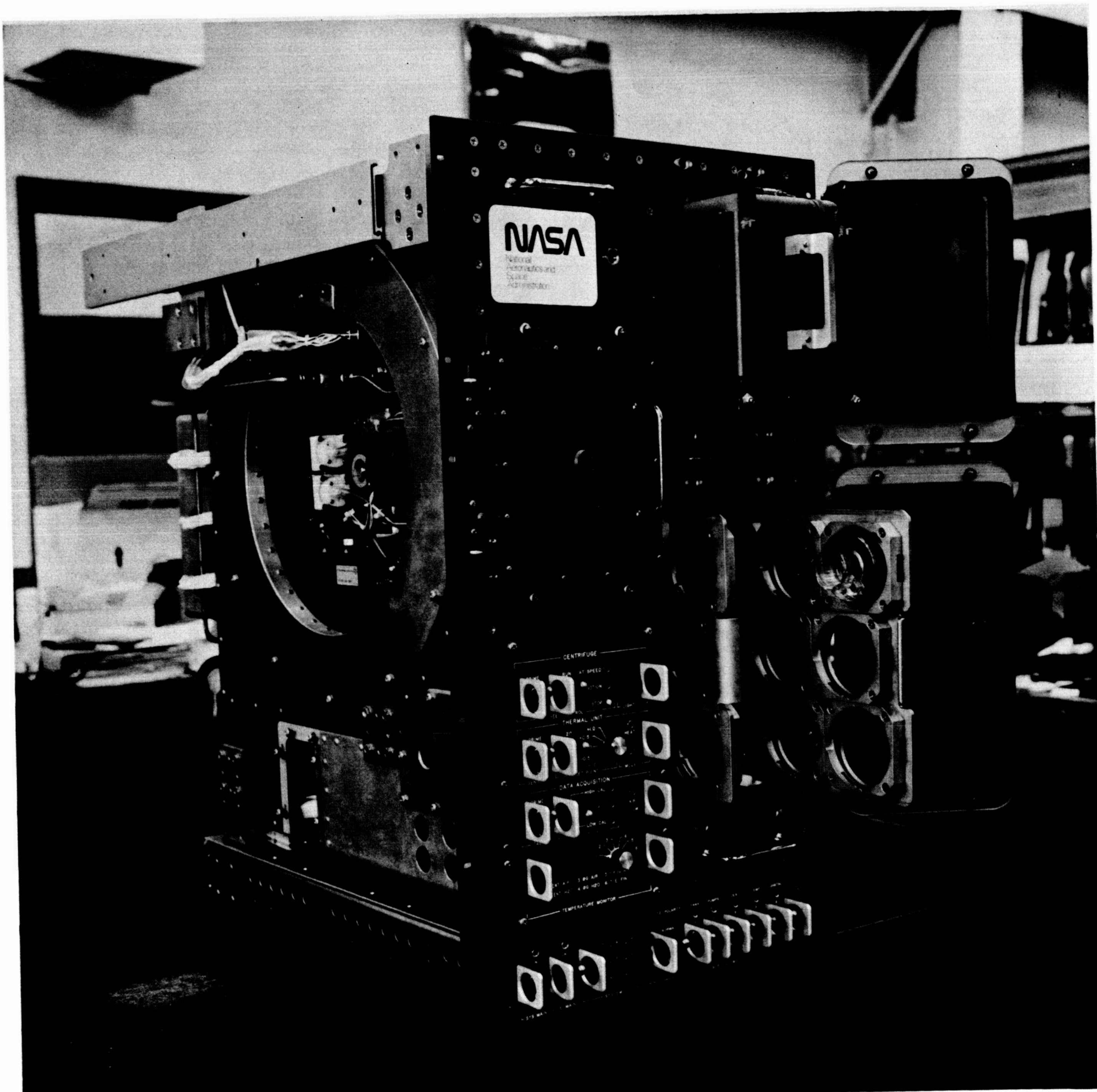
The egg chambers are small acrylic structures (approximately 3.0 × 3.0 × 3.5 in.) with valves for syringe access during experimental operations. Up to 56 chambers can be housed within the FEU at one time: 28 slots are provided on the centrifuge and 14 slots are provided on each of two trays in the 0-G storage section of the FEU. The chambers and trays are removable for use at the GPWS.

The data-monitoring system enables data (temperature, centrifuge rpm, airflow) to be output and sent to the ground during flight. Front panel controls will include temperature and rpm switches, digital readout of selected parameters, and necessary caution and warning lights.

Specifications:

Location	Fits in lower portion of single rack or lower portion of half of double rack; 19 panel units high (~33 in.), 5.2 in. protrusion from rack front
Weight	<160 kg (352 lb)
Power	28-VDC-conditions Spacelab +28-VDC for subsystems with DC/DC converters
Spacelab interfaces:	Spacelab liquid cooling loop Avionics air Cabin air Power Remote acquisition unit (RAU)

Frog Environmental Unit



General Purpose Work Station

STATUS: *COMPLETE (SLS-1 Verification Testing in Progress)*
FLIGHT: *SLS-1, SL-J, SLS-2*

The General Purpose Work Station (GPWS) is a broad-range support facility for general laboratory operations to be performed aboard the Spacelab. The GPWS can support animal experiments, biological sampling, and microbiological experimentation, and can serve as a closed environment for containment while routine equipment repair or other in-flight operations are performed.

The GPWS provides the necessary working space and accommodates the laboratory equipment and instruments required for many life sciences investigations. The unit is self-contained, apart from power, data, and cooling interfaces with the Spacelab, and is housed in a European Space Agency (ESA) Spacelab double rack. Laboratory work bench accommodations, including airflow, power, and lighting, are provided in a rack-mounted, retractable cabinet. This cabinet has a full-sized front door, allowing large experimental hardware to be mounted in the cabinet interior during flight. In addition, two crew members may simultaneously perform tasks inside the cabinet through ports on the front and side of the cabinet.

Support subsystems and capabilities include mounting, stowage, and alternating or direct current power supply for experiment-related equipment; control and containment of liquids and chemical vapors within the GPWS cabinet and contaminant control system; barriers preventing particle release to the Spacelab cabin, and the capability of hardware/animal transfer during experimental operations while a sealed working environment is maintained.

Although the unit has not yet been exercised during a 0-G flight, it has been utilized in ground simulation activities involving rodent dissection with tissue removal and fixation, rodent venous blood sampling, and frog egg manipulations with microscopic observations.

Specifications:

Size	Occupies one double rack
Weight	343.25 kg (765 lb)
Power	Nominal with an experiment consumption of 50 W; total consumption, 503 W
Spacelab interfaces	Water cooling Avionics air

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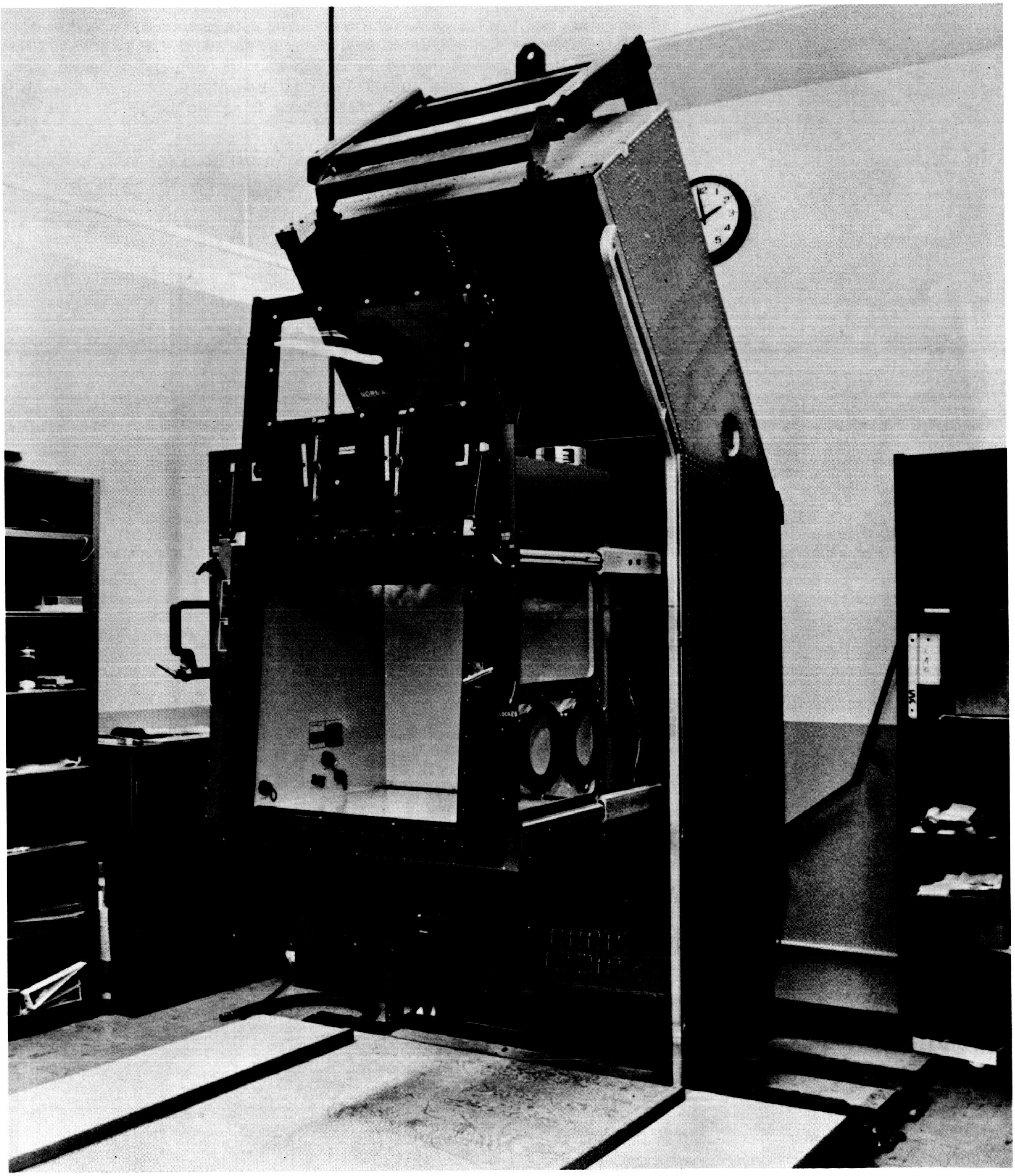


General Purpose Transfer Unit

STATUS: *COMPLETE*
FLIGHT: *SLS-1, SLS-2*

The General Purpose Transfer Unit (GPTU) was specifically designed to provide a second level of particle containment during transfer of rodents in cages between their holding facility and the General Purpose Work Station (GPWS).

The GPTU is made up of a lexan frame with sliding access door and a Tyvek sock which can be removed and replaced as it becomes soiled. The unit interfaces with the side access window installed on the GPWS and will open and close the side access window by means of a tab pull. Two quarter-turn fasteners (one on each side) mate with dowels in the side access window to secure the GPTU to the GPWS.

An adapter is provided on the rodent Research Animal Holding Facility to enable location of the GPTU in front of the rodent cage being installed or removed.

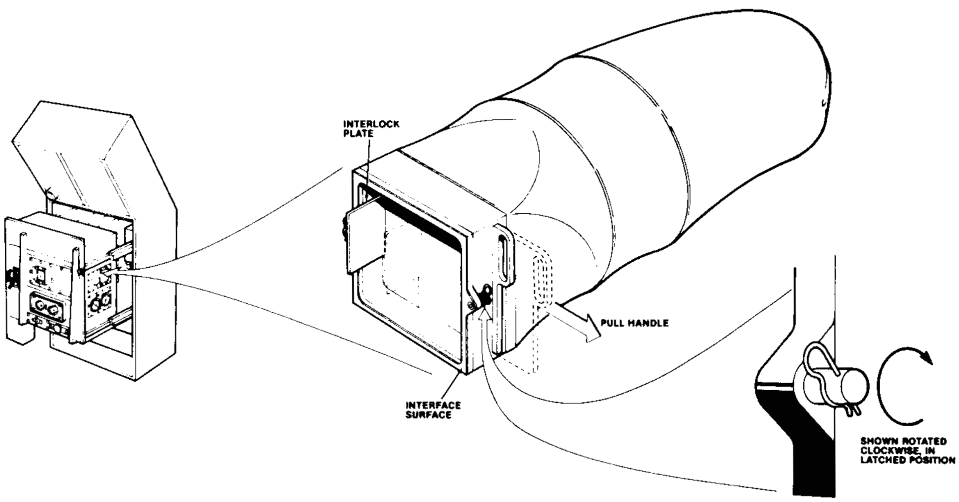
Specifications:

Weight .... 1.21 kg (2.66 lb)

Size .... 25 × 28 × 13 cm

Spacelab interfaces ...... There are no interfaces to Spacelab. All interfaces are to experimental hardware.

General Purpose Transfer Unit



Gravitational Plant Physiology Unit

STATUS: *DEVELOPMENT*
FLIGHT: *IML-1*

The Gravitational Plant Physiology Unit (GPPF) is designed to perform two specific gravitational plant physiology experiments, but may be adapted to various gravitropic, phototropic, circumnutational, or other studies. The GPPF occupies most of a Spacelab double rack and consists of the following equipment:

Culture Rotor Assembly: The culture rotor assembly contains two 1-g centrifuge rotors. Each rotor is designed to hold 16 plant cubes. The cubes can be attached to and removed from the rotors manually by a crewmember. The rotors can be started and stopped individually using the control unit.

Test Rotor Assembly: The test rotor assembly contains two variable-gravity centrifuge rotors. Each rotor has 16 positions to hold plant cubes. The test rotors operate independently to provide accurately controlled centripetal force in the range of g-levels between zero and unity (maximum 76.5 rpm). A stationary infrared-sensitive video camera is mounted just outside the envelope of each rotor. The rotors are designed to turn slowly at one revolution each 6 min past the video cameras. When a plant cube moves in front of the camera, infrared video of the plants inside the cube is taken and recorded on two redundant video tape recorders. The test rotors are independently programmed by crewmembers at the control unit.

Recording and Stimulus Unit (REST): The REST provides the capability for time-lapsed infrared video recording of the plant seedlings' positions in four cubes, both before and after a blue-light stimulus. Cubes are transferred to the REST manually by the crewmembers. The light pulse timing and recording sequence are programmed using the control unit. The light pulse is provided by a 1-W, tungsten filament lamp. A camera and recorder controlled by the microprocessor, take 5-sec pictures at 10 min intervals.

Video Tape Recorders: Two redundant video tape recorders (VTRs) record video images of the plants. Video tapes are changed manually by the crew members.

Control Unit: The control unit contains a modified Apple microprocessor which controls the operation of the rotors, cameras, REST, and VTRs. It also contains a video monitor, and a 24-character LED display which generates messages guiding and confirming inputs.

Mesocotyl Suppression Box (MSB): The MSB stimulates the plants with red light for up to 10 min which suppresses the growth of the mesocotyl. Four trays of plants can be loaded into the MSB at one time. The MSB is turned on by an on/off power switch and is activated with a mechanical timer.

Plant Cubes: The plants are planted into small wells in a tray containing an antipest-vermiculite mixture. The trays are placed in a light-tight cube which can attach to the rotors or the REST. At one end of the cube is a window constructed of an infrared filter sandwiched between plexiglass to permit infrared video of the plants inside. The cubes also have a transparent window which allows blue light to enter when the cubes are in the REST. Slides are placed over the transparent windows to prevent light from entering the cubes when not in the REST. The cubes also have a septum for gas sampling. When not on the rotors or in the REST, the cubes are stowed in the Plant Holding Compartment (PHC). The PHC can also hold other small items as stowage.

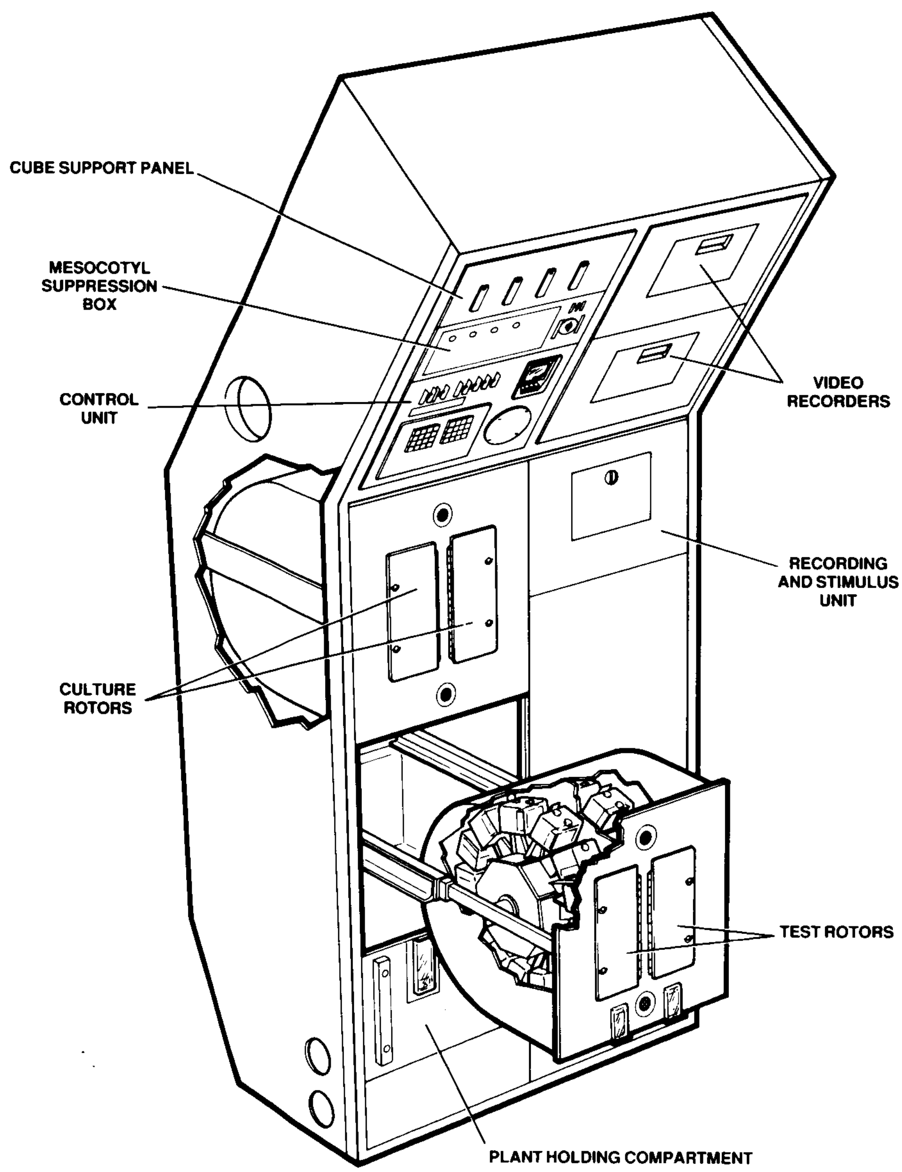
Specifications:

Size .... 1 double rack for all equipment

Power/Weight ....

Item	Power, W	Weight, kg
Culture rotor assembly	2.8	29.4
Test rotor assembly	2.8	36.6
REST	138.8	13.4
VTR F	30.0	23.0
VTR G	30.0	23.0
Control unit	51.2	24.4
MSB	77.0	5.0
PHC	N/A	10.5

GPPF Experiment Hardware



Plant Growth Unit

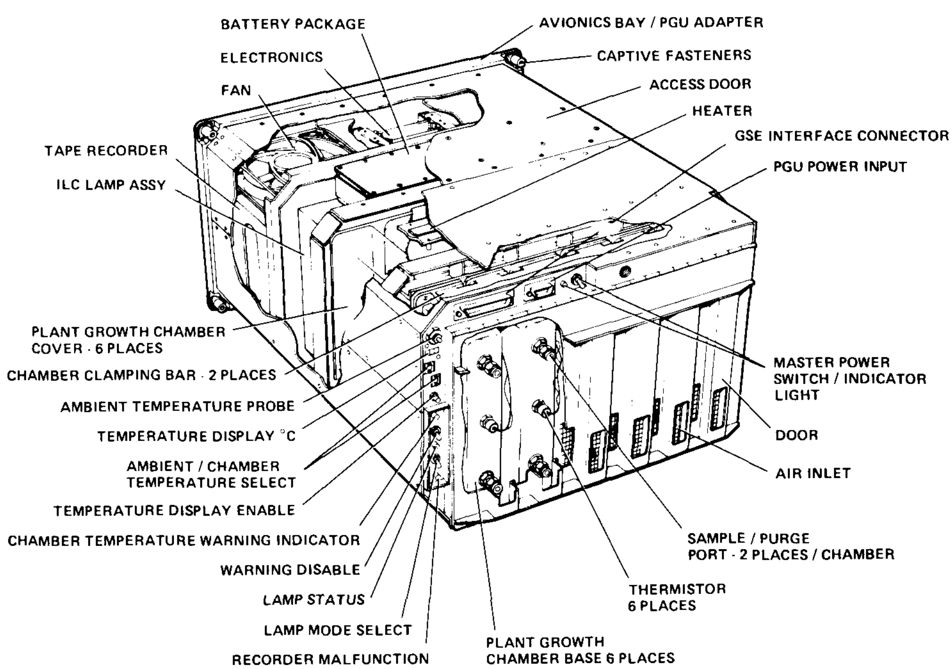
STATUS: *COMPLETE*
FLIGHT: *STS-3, SL-2*

The Plant Growth Unit (PGU) is a self-contained unit carried in the Orbiter middeck and designed to hold six removable plant growth chambers. Each chamber contains 16 seeds or seedlings between sheets of moist filter-paper-like material. Each chamber consists of a base containing two septum ports, a thermistor, and a lexan cover which is sealed to the base using a gasket. The chambers are placed into the PGU where the environment is controlled by a lamp module, a heater, and two fans. Diurnal cycles are adjustable. Temperatures and lamp status are recorded at intervals in flight by a tape recorder. The PGU replaces a storage locker in the Orbiter middeck; it can be placed into the Orbiter approximately 12 hr before launch and removed approximately 1 hr after landing.

Specifications:

Size	52 cm long × 45.9 cm wide × 27.4 cm high
Power	28-VDC; day 81.2 W; night 47.6 W
Weight	27.2 kg (59.84 lb)
Thermal control	Temperature in the PGU can be controlled only *above ambient*
Irradiance	75-μmol/m^2/sec Photosynthetic Active Radiation
Spectrum	Fluorescent (Vita-Lite)
Chamber size	19 cm long × 5 cm wide × 22 cm high

Plant Growth Unit



Plant Canister

STATUS: *COMPLETE*
FLIGHT: *ATLAS*

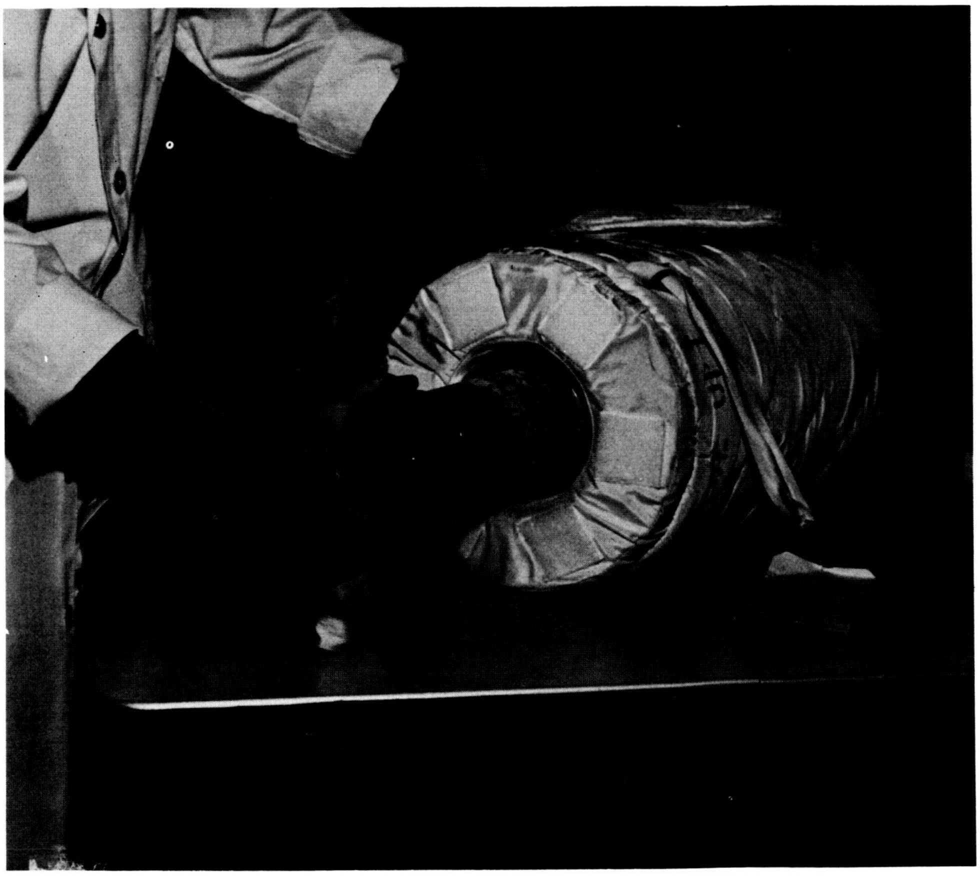
The plant canisters are used within the middeck and are loaded into their foam cutouts in the lockers during late access (L-12 hr). At a predetermined time on-orbit, the plant canisters are withdrawn from the foam and placed in LN2 passive freezers for preservation of the contained plants.

The units are designed to hold 15 corn plants each. The units are fabricated of aluminum of a thickness capable of withstanding approximately 11 psi external pressure. The units are composed of two sections which screw together and facilitate placement within the passive freezers.

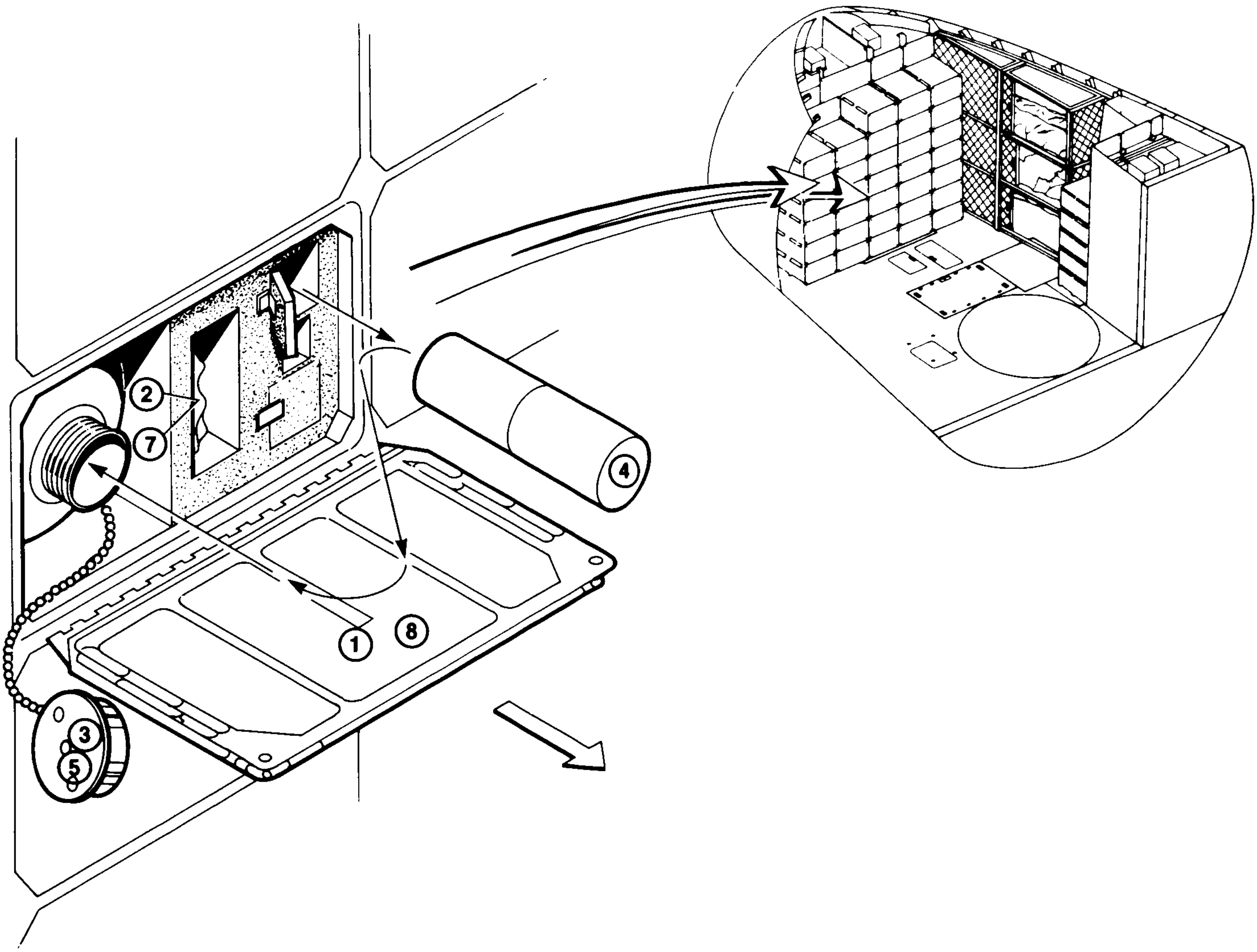
Specifications:

Size	16 cm high × 8 cm diameter at widest point
Weight	1.77 kg (3.9 lb) for each cylinder half
Interfaces	There are no interfaces other than the foam compartmented fitting into a middeck locker.

Passive Nitrogen Freezer Used In Atlas Middeck Plant Experiment



Plant Canister Middeck Location



Refrigerator/Incubator Module

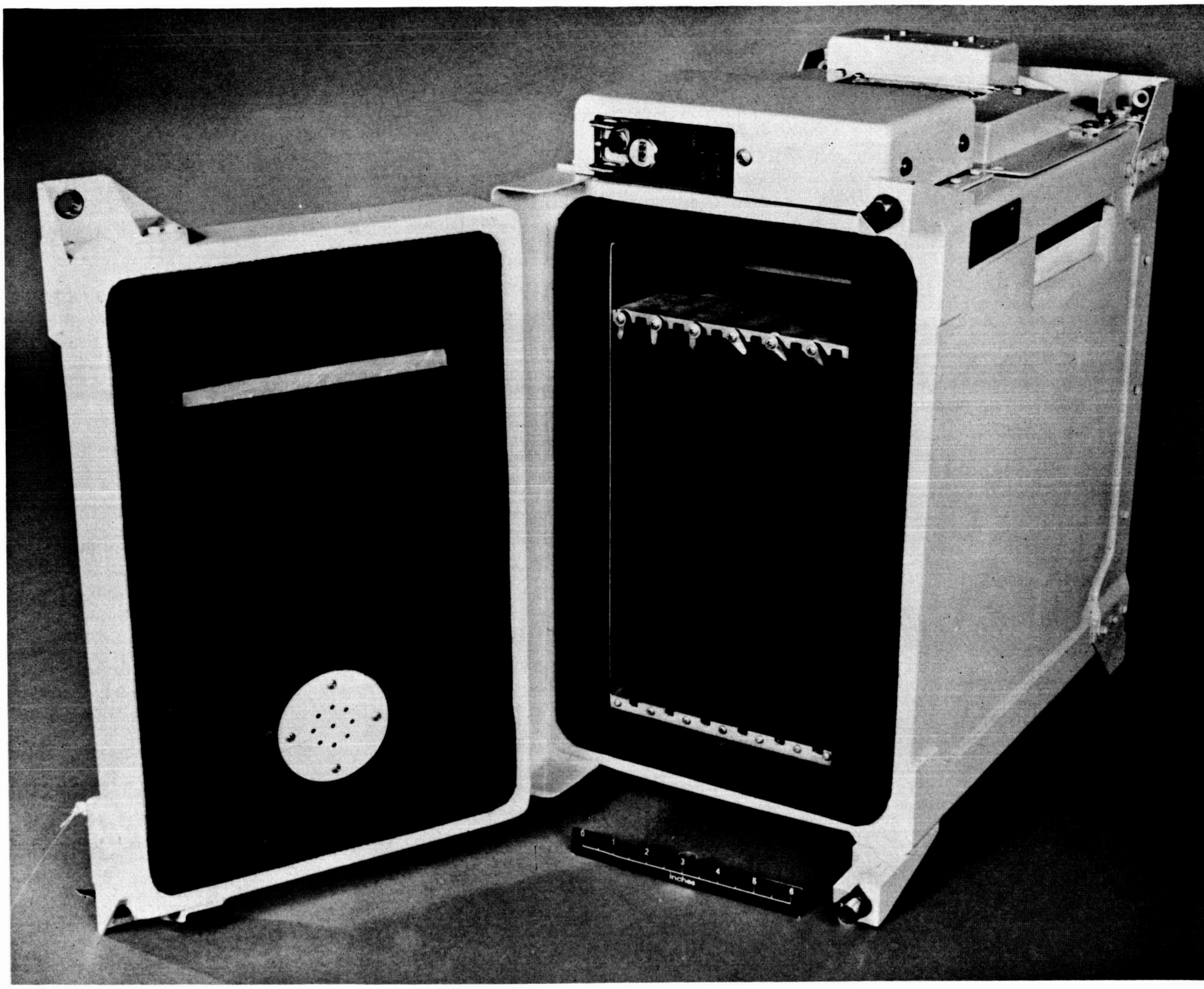
STATUS: *Under contract development from McDonnell Douglas; available May 1987.*
FLIGHT: *SLS-1, SL-J, ATLAS*

The refrigerator/incubator module is an active unit with a temperature range from 0° to 40° C. It is flown in place of a standard middeck stowage locker. The temperature is set using a front-mounted variable potentiometer with switching between the refrigeration and incubation modes occurring automatically. Front-mounted heat/cool LED indicators and a power switch are also provided.

Specifications:

Control system	Electronically controlled thermoelectric unit (TEU) referenced to an internally mounted platinum resistive thermal device (RTD)
Control setpoint	Manually adjusted from 0° to 40° C
Control stability	Temperature at reference sensor is maintained within ±0.5° C of setpoint for temperatures within 20° C of ambient
Ambient range	2° to 50° C
Weight	19.35 kg (43 lb)
Mounting	Four ME 128-0051B sleeve bolts, mount in place of standard stowage locker on Shuttle middeck forward bulkhead (left column only)
Internal volume	16,684 cm^3 16.40 × 25.88 × 36.98 cm 04.27 × 13.97 × 16.41 cm
External volume	27.89 × 49.15 × 48.90 cm
Power	84 W at 100% duty cycle; will vary from 0 to 100% depending on control setpoint and ambient temperature
Voltage	28 ±VDC

Refrigerator/Incubator Module



Research Animal Holding Facility

STATUS: *AVAILABLE JUNE 1988*
FLIGHT: *First version flown on SL-3, current unit under development is modification for particulate containment; SLS-1, SLS-2, SLS-3*

The Research Animal Holding Facility (RAHF) is a general-use facility for housing small animals to be used in life sciences experiments aboard the Spacelab. The RAHF will provide environmental control, food, water, illumination, and waste management for the animals on board.

The current system can accommodate a combination of twenty-four 350-g rodents or four 1-kg squirrel monkeys using either of three cage designs shown on the accompanying pages.

The two versions of the RAHF differ only in the design of the cage module to contain small rodents versus the larger primate. All other subsystems are identical. A cage module provides structural support, air ducts, lights, animal water system components, connections and wiring for electrical power and data systems, and temperature and humidity sensors. An Environmental Control System (ECS) is mounted on the back of each cage module to circulate conditioned air through the cages.

The cages are an integral of 12 drawers for the rodents which are removable for easy access to the animals. Removal of one cage drawer dictates removal of two animals (each drawer contains two tandem cage sections). Each cage contains a waste-management system plus individual feeders and watering lixits. Additional control can be exercised over temperature and day/night lighting. Protection against cross-contamination between crew and animal is provided through bacteriological isolation.

The data systems in the RAHF are designed to interface with the Spacelab data-acquisition systems.

Because the Spacelab x-axis is vertical during launch, the RAHF is on its side (horizontal) during this time. The RAHFs can be installed only on the port side of the Spacelab to orient the cage waste trays properly. In this position, animal cages are designed with the waste tray down in the 1-G direction to capture animal wastes during prelaunch and launch. During 0-G orbit, the normal airflow through the cage moves wastes into the waste trays. On landing, cages are oriented 90° from launch so that the 1-G vector is through the cage wall. To prevent animal wastes from building up on the cage walls, animals are recovered from Spacelab as soon as possible after landing.

General Specifications:

Capacity .... Provides capability to house rodents weighing up to 350 g or primates weighing up to 1200 g through all phases of the mission

Weight (total) .... 280 kg (616 lb)

Size .... Occupies 1.5 ESA racks

Power .... 324 W continuous operation; maximum thermal load is 850 BTU/hr for each RAHF

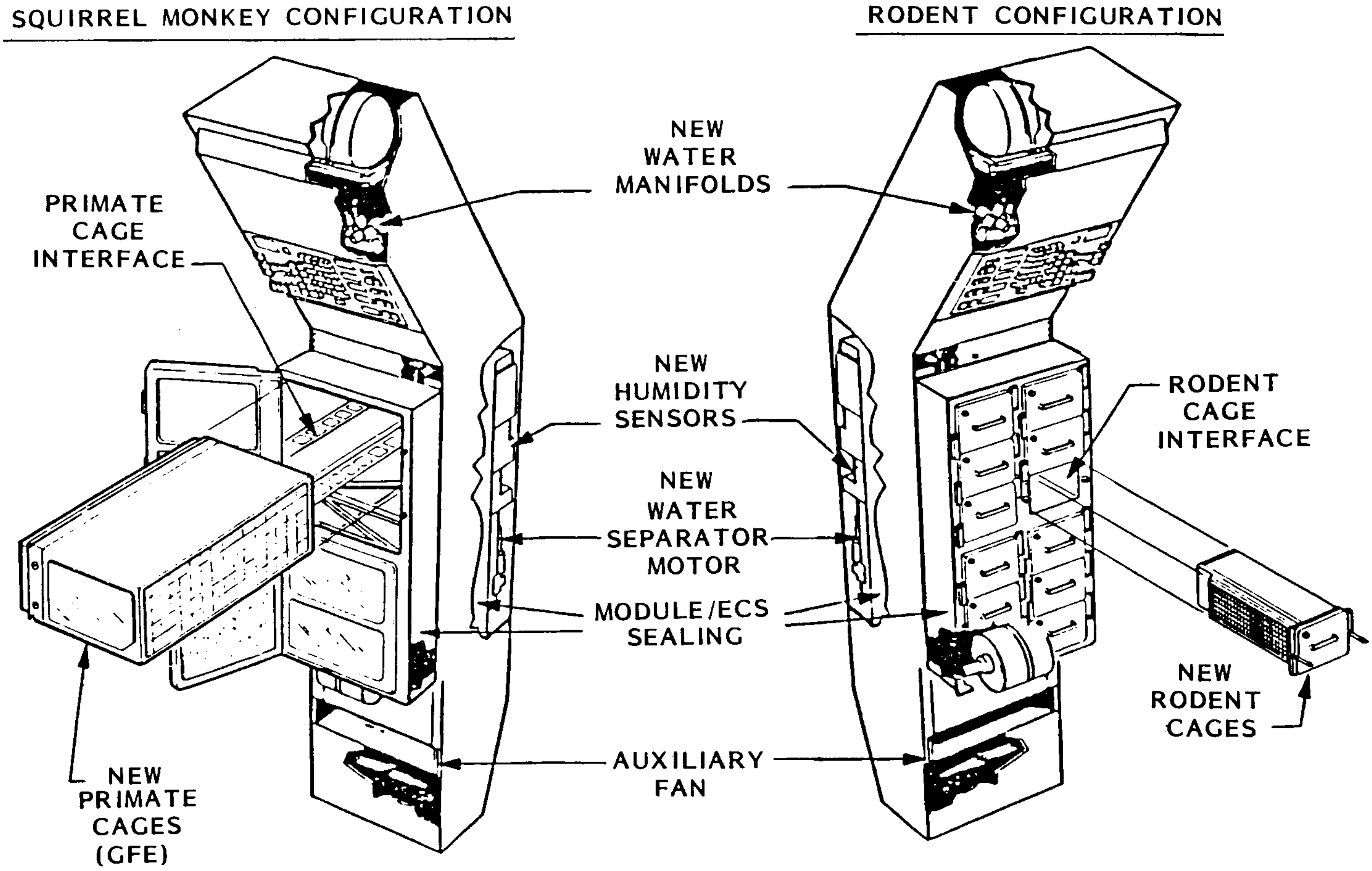
Operation .... 1-G or 0-G in horizontal or vertical position.

Before launch, the Shuttle is supported in a horizontal position on the launch pad. Animals are loaded into the RAHF cages approximately 24 hr before launch. Currently, this requires suspension of personnel, holding cages in a boatswain's chair, through the tunnel into Spacelab since vehicle doors are closed by L-72 hr. Postflight, cages are accessed through the tunnel also, but the vehicle is in a landed horizontal position which allows personnel to walk through the tunnel into Spacelab and retrieve the cages (usually within 3 hr).

RAHF Rodent Cage:

- Airflow through-top multilayer screens
  Smallest 150-μm opening
- Two Compartments—One 400-gm rodent maximum each; Compartment size 4 by 4¼ by 10 in.
- Ad lib water and feeding each compartment
- Compact food bars, each 0.9 by 1.187 by 16 in. long, presented by a constant-force spring to a feeding alcove in each compartment.
- Removable feeder cassette contains two food bars and expandable tape measures showing food bar length remaining.
- Water spigot provides a "water ball" replenished by rodent tonguing an activator lever.
- Water fed from two quick disconnects on the back of the cage and is measured to an accuracy of 0.5 ml.
- Removable waste tray contains ¼ in. thick charcoal and ½ in. thick absorbent wick, both used for odor and bacteria control.
- Rodent loading and access through two separate top doors.
- Front cover over cage blocks external light from entering transparent window.
- Cage lighting provided by external incandescent bulbs outside top cover.
- Internal cage activity monitor in each cage transmits a "prescence" signal when a 920-nm light beam is reflected by any part of the rodent.

Research Animal Holding Facility



Research Animal Holding Facility Primate Cage

STATUS: *Under modification; available January 1989*
FLIGHT: *SLS-2*

A cage to accommodate small primates, specifically squirrel monkeys, has been designed for installation into the Research Animal Holding Facility (RAHF). Each RAHF-compatible, small-primate cage supports an individual restrained squirrel monkey (1000–1200 g). The cage provides waste management, food and water dispensing and measurement, lighting, temperature, and odor control.

The individual primate cages can contain a primate restraint system, venous and arterial infusion systems with a blood-pressure sensor, urine collection system, and a feeding and watering system. The primates can be implanted with sensors to measure deep body temperature or other parameters. Heart-rate data can be extracted from the blood-pressure-sensing system. The primates can also have thermistors on the skin surface to measure temperature. A system of valves and syringes can be connected to the catheters to allow the infusion of saline and the withdrawal of blood. Each cage can contain a urine collection device which holds up to 35 ml each in tubes previously evacuated and capped with rubber diaphragms. The tubes are housed in a fraction-collector-type carousel. Urine produced by the monkey is transported to the empty urine container tubes via a tube enclosing the primate's penis. At set time intervals (4 hr), the evacuated urine containers are pressed against a needle at the end of the urine collection tube. The vacuum (in the evacuated tubes) draws off the urine into the empty urine tube.

The primates obtain water via a lixit valve. Water consumption is ad lib and is monitored. Food is obtained from a food pellet dispenser when the primate presses a lever a set number of times. The number of taps required and the time interval between pellets can be programmed by selectable switches on the motor controller in the front section of the cage. Normally, the switches are set to the monkey's trained program. A relay is actuated whenever a pellet is dispensed from the feeder, and a pellet count is recorded on the RAHF data system.

Primate experiment objectives can include collecting in-flight data from indwelling catheters for pressure monitoring and periodic blood sampling. A system of valves and syringes is connected to arterial and venous catheters which allows infusion of saline solution and withdrawal of blood.

A spring motor pump (nonelectrical) provides constant flushing of arterial and venous catheters and is designed to operate reliably for a minimum of 9 days without electrical power. Two pressure transducers allow pressure measurement in each polyethylene catheter line. A syringe, in the front of the cage just behind the urine carousel, is fixed into the catheter line to eliminate any air bubbles that may enter the catheter lines at the catheter-monkey interface. Three-way valves enable the crew to make blood draws, and to perform emergency flushing of the catheter lines.

Each cage has a perforated stainless steel top and a grid floor which allows ventilation and entrapment of feces in the waste trays. The cage is divided into three sections. The front third of the cage contains the feeder and the urine carousel, controller, and signal conditioner box. The rear third houses the power distribution box. The monkey is seated in the center third of the cage. Access to the monkey is through a hinged front door, through the cage top, or through a side wall panel behind the monkey. The rear third of the cage houses a power distribution box, the infusion motor, and syringes. Twelve incandescent lights in two rows are mounted on the RAHF wall above each cage. Light-intensive and ambient cage temperature are monitored by transducers mounted in the rear cage partition.

The EPSP shall provide 28-VDC power to the Data Select Panel (DSP), which in turn shall channel breaker-protected 28-VDC to the four cage assemblies. In addition, 110-VAC, 400-Hz power (from DC/AC connectors in the DSP) shall be provided to each cage for feeder and urine carousel operation.

The unit may also be used to transfer a variety of other biological specimens or hardware within the Spacelab, as required.

Specifications:

Cage size .... 21.69 cm wide × 36.91 cm high × 53.34 cm deep

Weight (empty) .... 18.3 kg (40.26 lb)

Primate Restraint Chair

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STATUS: *COMPLETE*
FLIGHT: *SLS-2*

The primate restraint chair is designed to maintain a small primate (squirrel monkey) under stable physiological control. All units are intended for use within the Research Animal Holding Facility (RAHF) primate cage configuration. When utilized, the monkey rests on a perch in the cage where he has direct access to the cage feeder alcove and water lixit. He is restrained by a soft mesh jacket with loops that slip over vertical cylindrical rods. The restraint provides comfortable support and protects all physiological monitors and sensors from interference by the animal. A soft waist divider may also be installed if the animal is instrumented with any of the following: a urine catheter, vascular catheters, or skin sensors. The units may be laundered and sterilized with ethylene oxide for reuse.

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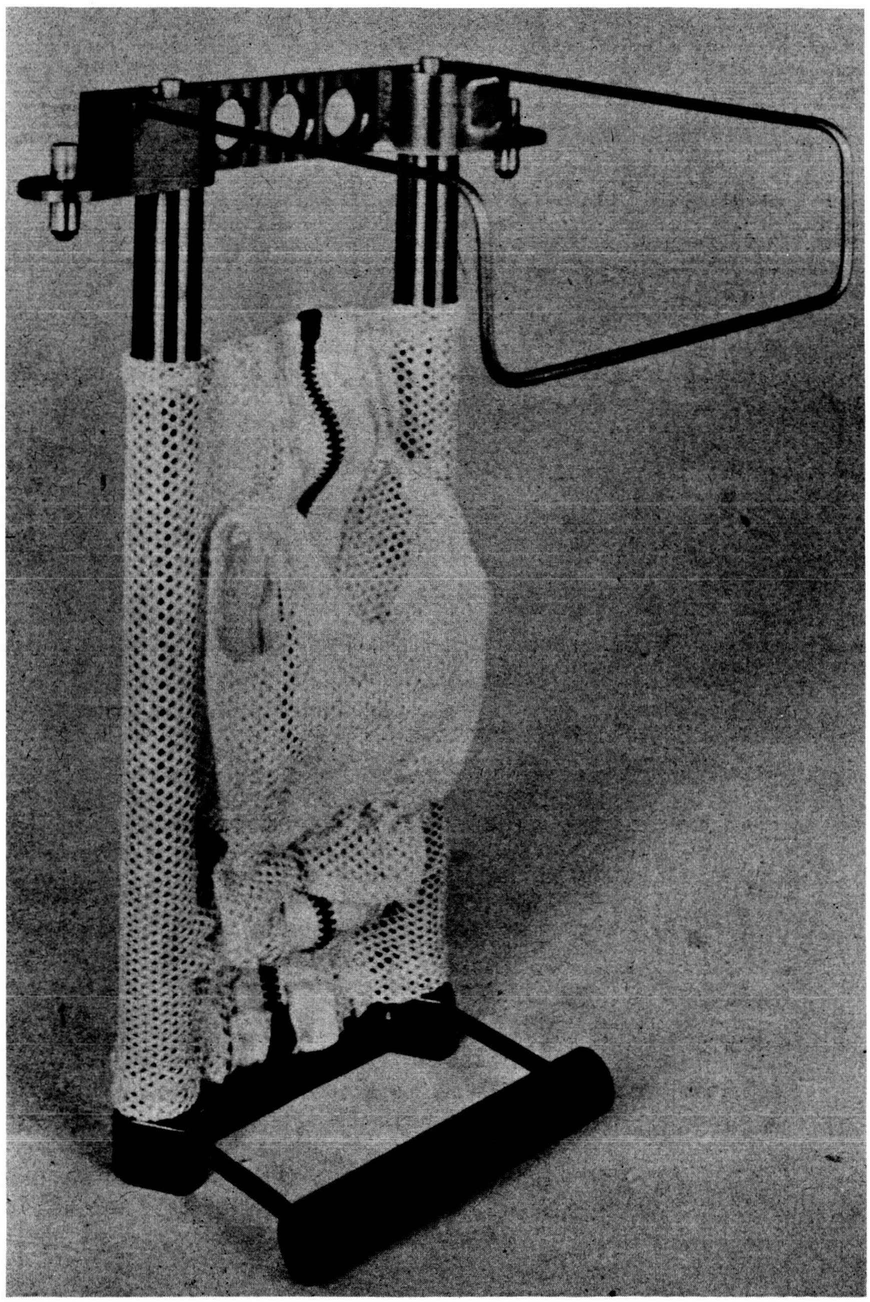
Primate Restraint Cage



Primate Biorhythm 8-Channel Recorder

STATUS: *COMPLETE*
FLIGHT: *TO BE DETERMINED*

The instrumentation in the primate biorhythm recorder system consists of transducers and a self-contained, solid state recorder for measuring skin, deep-body, and ambient temperature and heart rate for two restrained Rhesus monkeys. The skin temperature transducer is a very small thermistor (Yellow Springs Instrument Co., OH), which is held against the bare skin. The deep-body temperature transducer may be either a hard-wired or a telemetry unit and is provided by the user. Heart rate is derived from an ECG signal provided by the user. The recorder is a digital unit manufactured by Vitalog, Inc., Redwood City, CA. It accepts 0- to 5-VDC analog inputs and stores corresponding digital values in a resident solid-state memory. The sample rates and input ranges may be modified. Data may be read out onto a separate data transfer unit (based on an Apple IIe computer). This transfer must be accomplished within the lifetime of the internal batteries. The battery pack has a shelf life of about 1 yr and will operate the recorders continuously for about 30 days. The flight packaging and battery packs will be provided by L&M Electronics, Daly City, CA.

Specifications:

Sensor parameter	Ambient temp., ° C	Heart rate, bpm	Skin temp., ° C	Internal body temp., ° C
Range	55–85	TBD[a]	23–39	32–42
Sampl. Freq.	1/30 min	1/5 min	1/5 min	1/5 min
Accuracy	0.5°	TBD	0.1°	0.1°

[a] to be determined

Weight .... 2.45 kg (5.39 lb)

Size .... 15 × 8 × 19 cm

Rodent and Primate Activity Monitors

STATUS: *COMPLETE WITH RESEARCH ANIMAL HOLDING FACILITY DELIVERY*
FLIGHT: *SL-3, SLS-2, SLS-2*

Each rodent and primate cage compartment within the Research Animal Holding Facility (RAHF) contains one activity monitor that records general animal movement. Each monitor consists of an infrared light source and sensor mounted on the right side of the cage with reflector tape mounted on the left side of the cage. When the animal breaks the light beam and therefore the circuit, a counter is electronically advanced one pulse. The counter reading is recorded by the data system for transmission to the ground in real time or near-real time. The units were utilized during the flight of SL-3 but were found to be ineffective near the end of the flight because of the high degree of clogging by particulate matter loose within the cage. The modified RAHF (to be flown in SLS flights) has an extended hood over the monitor for protection from particulate contamination within the cage.

Individual specifications are not listed since the unit is an integral part of the entire cage system contained within the RAHF module.

Rodent Decapitator

STATUS: *DEVELOPMENT*
FLIGHT: *SLS-2*

The rodent decapitator is used to sacrifice small rodents in flight. The unit is a hand-operated device designed for sacrificing rodents weighing up to 500 grams. The decapitator consists of two razor-sharp blades opposite each other. The lower blade is stationary while the upper blade travels up and down via a handle and mechanical linkage. The handle can be configured for either left- or right-hand operations. (For all intents and purposes the functioning mimics the standard 1-G operated laboratory rodent decapitator.) The exposed sharp edges are secured when the unit is not in use. Utilization in 0-G is facilitated by means of suction cups on the base and a supporting edge such that the unit must be operated on a level and smooth surface.

Specifications:

Weight .... 2.2 kg (5 lb)

Dimensions .... 15.24 × 20.32 × 25.40 cm

Use location .... Inside General Purpose Work Station

Rodent Restrainer

STATUS: *COMPLETE*
FLIGHT: *SLS-2*

The rodent restraint is used to confine a rat with minimal stress while intraperitoneal and tail injections, blood sampling, and central and peripheral cardiovascular measurements are performed. The unit provides a nose cone and is made of plexiglass to allow easy observation of the animal during all operations. Velcro straps are used as closure devices to facilitate timely housing of the animal. Use of the unit is recommended within the General Purpose Work Station.

Specifications:

Size .... 10.16 × 20.32 × 4.0 cm

Weight .... 0.454 kg (1.0 lb)

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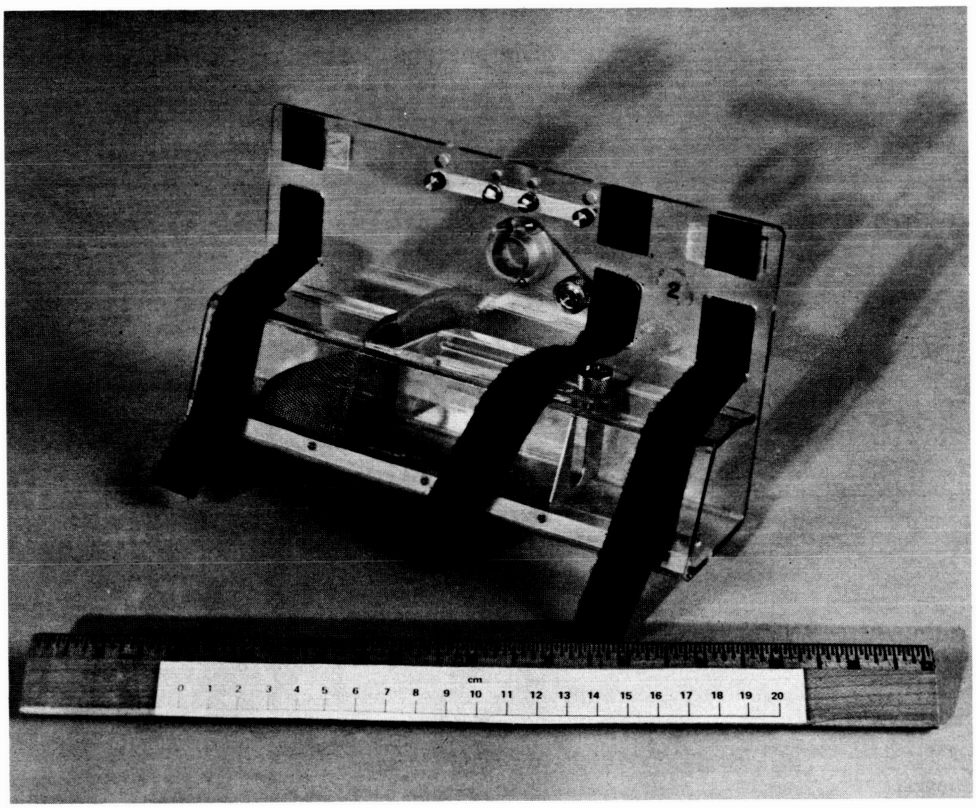
Rodent Restrainer



Veterinary Kit

STATUS: *COMPLETE*
FLIGHT: *SL-3, SLS-1*

The Veterinary Kit contains provisions which can be used for emergency care of squirrel monkeys and rodents during flight. The kit contains a metal plunger, 2-cc glass syringes filled with Buthanasia and with Prochloroperazine, antibiotic ointment, 35-cc fluid syringes with stopcocks, 25-gage butterfly needles, 3-in. gauze rolls, 2-in. gauze packets, bandage tape, Wash 'n' Dri packets, face masks, Kimwipes, bandage scissors, mosquito forceps, a screwdriver, disposable gloves, surgical gowns, iodine prep packets, primate contingency watering cups, and lixit assemblies. These items are organized within a rectangular cloth container having internal removable panels and pockets. The kit can be stowed in either the Orbiter, the middeck, or in Spacelab.

Specifications:

Power .... N/A

Volume .... 9.52×10^{-3} m^3

Weight .... 1.52 kg (3.35 lb)

Dimensions .... 18 cm long × 23 cm wide × 23 cm high

Veterinary Kit